Coupled Receiver/Decoders for Low-Rate Turbo Codes

Residual carrier power needed for recovery of phase would be reduced.

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Coupled receiver/decoders have been proposed for receiving weak single-channel phase-modulated radio signals bearing low-rate-turbo-coded binary data. Originally intended for use in receiving telemetry signals from distant spacecraft, the proposed receiver/decoders may also provide enhanced reception in mobile radiotelephone systems.

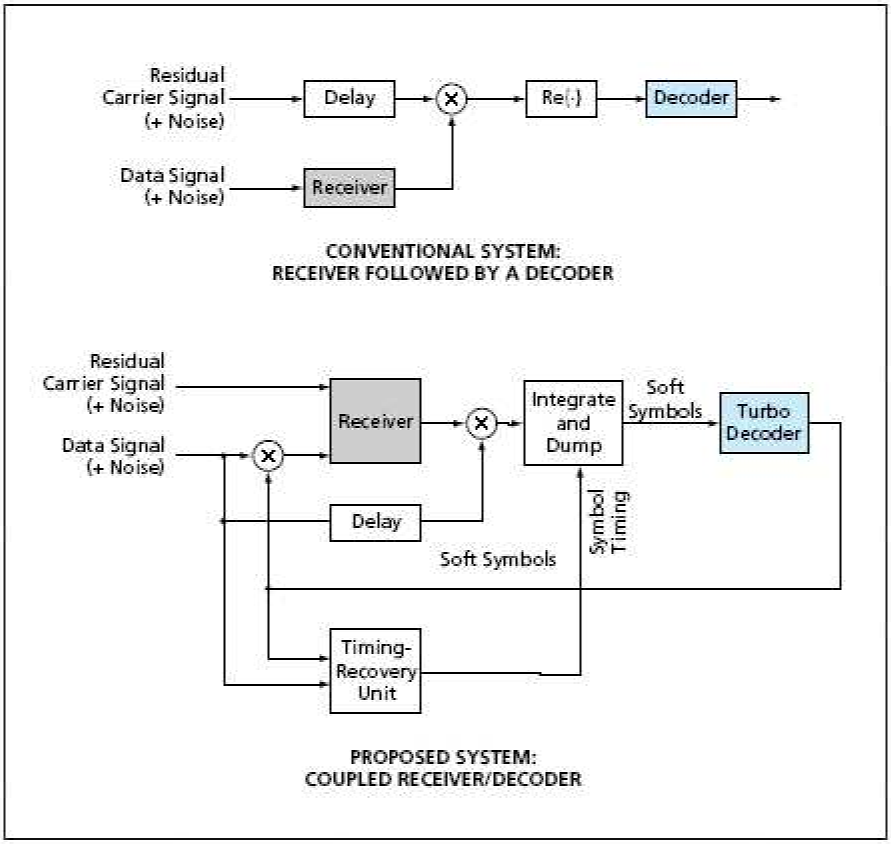
A radio signal of the type to which the proposal applies comprises a resid-ual carrier signal and a phase-modulated data signal. The residual carrier signal is needed as a phase reference for demodulation as a prerequisite to decoding. Low-rate turbo codes afford high coding gains and thereby enable the extraction of data from arriving radio signals that might otherwise be too weak. In the case of a conventional receiver, if the signal-to-noise ratio (specifically, the symbol energy to onesided noise power spectral density) of the arriving signal is below approximately 0 dB, then there may not be enough energy per symbol to enable the receiver to recover properly the carrier phase. One could solve the problem at the transmitter by diverting some power from the data signal to the residual carrier. A better solution — a coupled receiver/decoder according to the proposal — could reduce the needed amount of residual carrier power.

In all that follows, it is to be understood that all processing would be digital and the incoming signals to be processed would be, more precisely, outputs of analog-to-digital converters that preprocess the residual carrier and data signals at a rate of multiple samples per symbol. The upper part of the figure depicts a conventional receiving system, in which the receiver and decoder are uncoupled, and which is also called a non-data-aided system because output data from the decoder are not used in the receiver to aid in recovering the carrier phase. The receiver tracks the carrier phase from the residual carrier signal and uses the carrier phase to wipe phase noise off the data signal. The receiver typically includes a phase-locked loop (PLL) or Costas loop that requires no delay or perhaps a single sample delay.

The lower part of the figure depicts a basic coupled receiver/decoder — a data-aided system that would implement an iterative receiving/decoding process. The receiver would include a PLL or a Wiener filter that, to the extent possible, would track the residual carrier signal, wipe phase noise off the data signal, then send the result to the turbo decoder. Recovery of timing could be effected by, for example, a digital transition tracking loop (DTTL) or other, similar loop. The first iteration of turbo decoding would yield soft data symbols, which would be sent back to the receiver for use in softly wiping off the data signal in an effort to recover the residual carrier signal. The wiped signal would contain a relatively large carrier-phase component that could be tracked by use of a second Wiener filter.

The refined phase estimate generated by the second Wiener filter would be used to wipe the phase noise from a delayed replica of the incoming data signal. The resulting refined data signal would then be sent to the turbo decoder for the second iteration. The soft symbols from the second iteration would be sent back to the receiver as in the first iteration, and the process repeated.

For recovery of timing, the output of the turbo decoder would be used in place of what, in a usual DTTL, would be a transition-detector arm, in which hard decisions on consecutive symbols are based on raw symbol-by-symbol channel input, with no coding gain. The use of the turbo-decoder output would afford the benefit of the coding gain, thereby improving the output of the transition detector. Overall, the two-way communication between the receiver and the decoder would improve the performance of both the receiver and the decoder.



A Coupled Receiver/Decoder would utilize data feedback from its turbo decoder, whereas a conventional receiver does not utilize data from the turbo decoder that follows it.

This work was done by Jon Hamkins and Dariush Divsalar of Caltech for NASA's Jet Propulsion Laboratory. For further information, access the Technical Support Package (TSP) free on-line at www.techbriefs.com/tsp under the Electronics/Computers category.
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